Section III
Energy-Saving Measures

What are the most cost-effective energy-saving measures for your building? That depends on numerous site-specific factors such as the condition and size of the building, the climate, and the cost of fuel in your region. This section covers various measures for improving the energy efficiency of the building's exterior or shell; the mechanical systems; the hot water systems; lighting; and appliances.

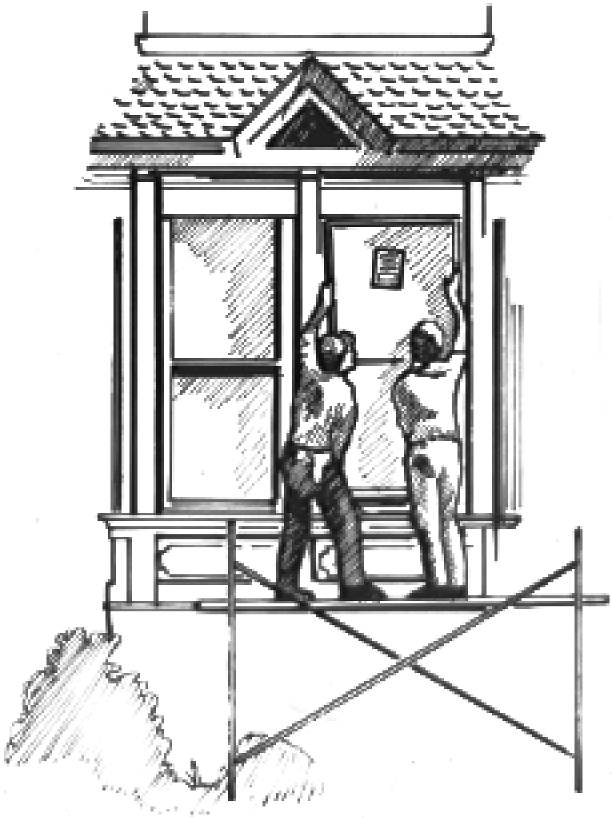
Generally speaking, if your facility is a residential building, your most cost-effective options include the following:

- air sealing with a blower door (see page 13)
- increasing attic insulation
- low-cost furnace cleaning, tuning, and repair (see Section IV)
- installing night set-back thermostat controls
- adding water-heater insulation
- installing low-flow showerheads.

If your facility is a centrally heated, multifamily building, your primary energy-saving strategy should be to improve your heating system. Consider installing more efficient models if you need to replace your heating and cooling equipment because of safety or other issues. This holds true for single-family and multi-family residential structures as well as facilities that support non-residential programs such as day centers or social service delivery centers.

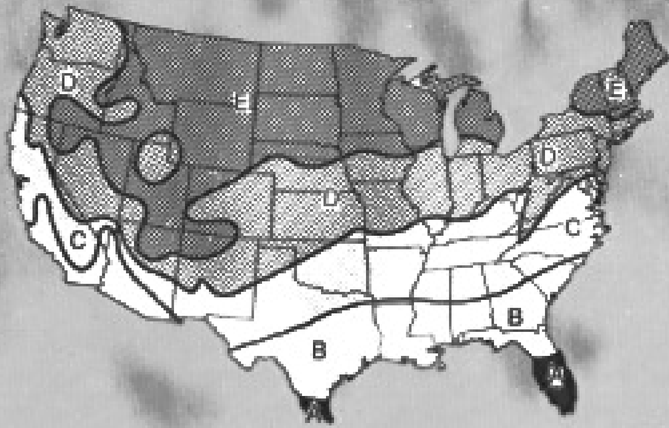
Building Shell

The shell is the building's basic exterior. It is made up of structural features such as floors, walls, roof, ceiling, windows, and doors. The "energy performance" of your building, or its energy efficiency, depends largely on how well its shell can withstand the environmental influences of sun, wind, and temperatures, both high and low. The key to designing a comfortable, energy-efficient building is to make the most of the beneficial effects of these



Insulation Guidelines

Insulation guidelines aren't possible for building renovations because the size of cavities in existing walls and roofs determines how much insulation you can add. This table provides guidelines for recommended insulation levels for new homes heated with oil or gas.[a]



A = less than 1000 HDD[b]
B = 1001-2500 HDD
C = 2501-4500 HDD
D = 4501-6000 HDD
E = greater than 6000 HDD

Feature	Zone A	Zone B	Zone C	Zone D	Zone E
Ceiling insulation	R-30	R-30	R-38	R-38	R-49
Wall insulation	R-11	R-13	R-19	R-19	R-19
Floors over unheated spaces	None	R-11	R-19	R-19	R-19
Foundation walls of heated spaces	None	None	R-6	R-11	R-11
Slab foundation perimeter	None	R-5	R-7.5	R-7.5	R-7.5
Number of glass layers of windows	1	2	2	3 or low-e[c]	3 or low-e
Storm door or thermal door	No	No	No	Yes	Yes

[a] For residences heated with electricity, recommendations for wall and ceiling insulation are slightly higher.
[b] A HDD is the difference between the mean outdoor temperature for a day and 65°F.
[c] Low-e windows have a low-emissivity coating that greatly enhances their energy efficiency.
Source: U.S. DOE, *Insulation*, Jan. 1988, DOE/CE-0180. Also, the HUD Minimum Property Standards.

environmental influences and minimize their harmful effects.

Insulation

The cost-effectiveness of an insulation retrofit—adding insulation to an existing building—varies depending on your building and your climate. Adding insulation to the attic of an uninsulated single- or multifamily building makes sense if you have easy access through a hatch. If you already have attic insulation, increasing it up to R-30 has a payback period of generally less than 10 years in a cold climate.[1] The cost of contractor-installed

[1] R value refers to the resistance to heat flow of an individual material. The higher the R value, the better the resistance to heat flow.

attic insulation is approximately \$0.03–\$0.05 per square foot per unit R-value for insulation placed on the attic floor.

Walls in existing buildings tend to be more difficult and more expensive to insulate than attics. If you want to insulate the cavity walls of a building with exterior wood or applied siding, you can remove the siding and blow insulation into the cavity. After doing this, patch the holes in the exterior sheathing and replace the siding. On average, the payback for this type of a retrofit is 10 years for single-family homes in cold climates.

If your building has masonry walls, you can add insulation in one of three ways. First, if the wall has a cavity within the masonry or between two walls of brick, you can insulate it as we described in the previous paragraph. Second, if there is no cavity, you can attach rigid insulation to the interior or exterior walls along with new interior drywall or exterior siding. Third, you can add framing and batt insulation to the interior walls along with new drywall. These methods are more costly than blowing insulation into an uninsulated cavity unless you are replacing the drywall or exterior siding as part of the building renovation.

Windows

Adding storm windows or replacing single-pane windows with more efficient ones may be difficult to justify solely from the standpoint of energy savings. For single-family or multi-family residential structures in particular, window replacements generally have greater than 20-year paybacks. Exceptions to this might include buildings in very cold climates

Air Sealing

The technique of air sealing is significantly more cost-effective than caulking and weatherstripping alone. It enables you to pinpoint exactly where your building shell needs tightening. The technique works as follows: A weatherization crew places a diagnostic tool called a blower door in an exterior doorway and shuts all other doors and windows. As the blower door operates, it creates a vacuum in the house, drawing outside air into the house through any possible opening. Then these air leaks are identified and sealed. The crew stops the process when infiltration is reduced to a level that is appropriate to the building. The recommended infiltration for residences is at least 15 cubic feet per minute for every person.

Air sealing is recommended for single-family homes and is still being evaluated for multi-family buildings. Your county weatherization office may be able to provide blower door testing for your building (see Section V).

or in locations with high fuel costs. Paybacks for multifamily buildings typically are better—from 10 to 20 years. Paybacks differ between single- and multifamily buildings because the latter tend to be masonry. In masonry buildings, window replacement is one of the few measures available to improve the energy efficiency of the building shell.

Although energy savings alone may not warrant window improvements, other issues may, such as comfort. If your staff and residents spend a lot of time indoors, more energy-efficient windows will reduce uncomfortable drafts. Replacing windows also improves the value of the property and could possibly reduce maintenance. If vandalism is a problem in your neighborhood, however, installing energy-efficient windows may not be cost effective because they are much more expensive to replace than single-pane windows.

If you do consider upgrading your windows, two options are double-pane and low-emissivity (low-e) windows. Double-pane windows cut heat loss through the window in half. These windows—or single-pane ones with storm windows—are recommended throughout the United States with the exception of the most southern parts of Florida and Texas.

Low-e windows combine a special coating with a double-pane window. The low-e coating, placed between the two panes of glass, reflects heat back to its source: inside in the winter and outside in the summer. Because they insulate 30% better than a double-pane window, these windows are recommended in cold northern states and the Rocky Mountain region.

The window frame and spacers between the panes of glass and frames also affect a window's energy performance. Your best choices are wood or aluminum frames with a thermal break (an insulating element that retards heat from passing through the frame to the outside).

Sun Control

Unwanted sunlight can overheat your building in the summer and increase your cooling costs. Shading your windows is strongly recommended in hot climates where sun entering windows can account for 30% of air-conditioning loads. Sun control measures are generally very cost effective in centrally cooled buildings.

You can prevent overheating of interior spaces by adding vegetation, or exterior or interior shading devices. Vegetation and exterior shading devices work better than sun shades because the heat absorbed by the device is dissipated outdoors rather than indoors. Examples of exterior devices are overhangs, awnings, exterior blinds, and solar screens (typically black, louvered aluminum).

To shade from the inside, you can use reflective window films. These are polyester sheets with a transparent aluminized coating on one side.

Comparing Fuel Costs

What is the relative cost of fuel for heating? This chart compares the costs of providing 1 million Btu using the following options: electricity (electric resistance heating or heat pump), oil, and gas. You can see that a heat pump or a gas furnace is the least expensive way to heat and that electric resistance heating is clearly the most expensive option.

1989 Average Fuel Cost	Cost/million Btu
Electricity ($0.074/kWh)[a]	$21.68 (for electric resistance heating) $ 7.47 (for a heat pump)[b]
Oil ($1.25/gal)	$12.07
Gas ($0.53/CCF)[c]	$ 7.57

[a]kWh = kilowatt-hour. There are 3413 Btu of energy in 1 kWh.
[b]Heat pump operation is above 40°F (outside temperature).
[c]CCF = 100 cubic feet. At sea level, there are 100,000 Btu of energy per CCF.

Mechanical Systems

Wise selection and maintenance of your building's mechanical systems—furnace or boiler, ventilation, and air-conditioning—can make a big difference in your energy savings.

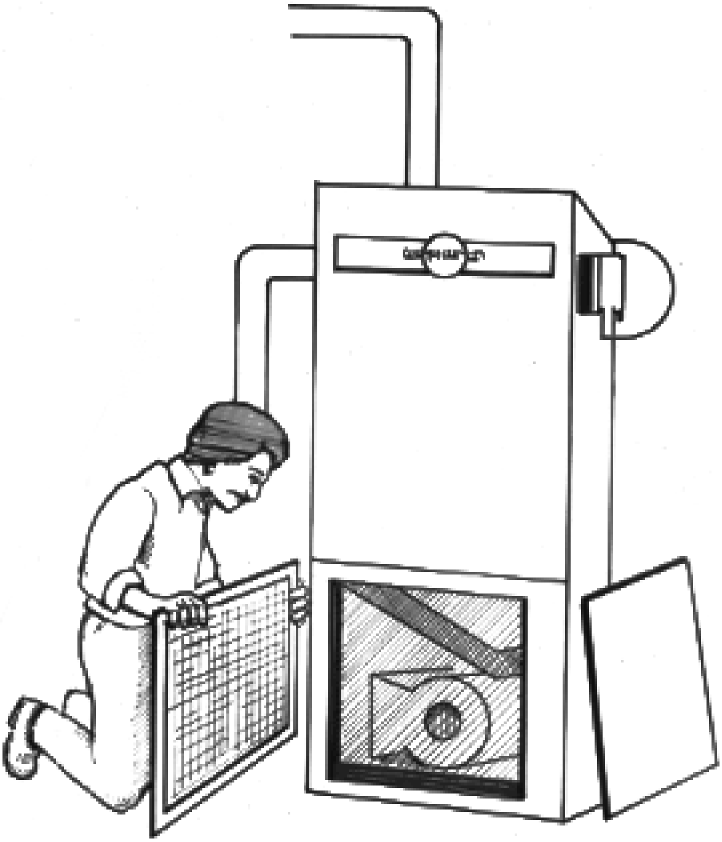
Furnaces and Boilers

Your building is heated by oil, gas, or electricity. Oil or gas heats a building in one of two ways: a furnace heats air directly, or a boiler heats water that is piped through the building to heat air. Electricity also provides heating in two ways: a heat pump or resistance heating that heats air or water directly.

An electric heat pump is essentially an air conditioner that can operate in reverse. In winter the heat pump extracts heat from outside and moves it inside; in the summer, the heat pump removes heat from the inside air to cool the space and dumps the heat outside. Heat pumps work well in climates where winter temperatures generally exceed 30°–40°F. They are not as cost effective to operate in cold climates because they need to be supplemented with electric resistance heating when the outside temperature drops below about 40°F.

The relative cost of heating with oil, gas, or electricity varies across the country. Natural gas is the most common heating fuel largely because of its lower cost and availability; you can heat with gas for about one-third the cost of electric resistance heating. Electric resistance heating is the least costly heating system to install but the most expensive to operate.

You can benefit from retrofitting a furnace or boiler with energy-saving devices. Paybacks for such devices for both single- and multifamily buildings tend to be relatively short (under 6 years). The following retrofit measures may be cost effective in your building:



- a flame retention burner (reduces oil consumption by 14%–25% for oil-fired furnaces)
- an electronic ignition (saves energy by eliminating a constantly burning pilot light in gas-fired furnaces)
- vent damper (reduces heat loss up the flue during the off-cycle)
- improved temperature controls for boilers
- night set-back controls for all furnaces and boilers.

Another measure that can result in large energy savings is zoning, which allows you to reduce the temperature in unoccupied rooms by using multiple thermostats. Your energy savings depend on the cooperation of your staff and residents because zoning affects their lifestyle. For example, if you provide heat to only one zone where residents congregate on cold winter nights, you will realize greater energy savings than if you have to heat numerous zones.

If you need to replace your oil- or gas-fired furnace or boiler, consider buying a high-efficiency one. Although its initial cost is generally higher than that of a conventional one, a high-efficiency model will use less fuel and save you money in the long run. You can determine which systems are most efficient and burn less fuel by comparing the Annual Fuel Utilization Efficiency (AFUE) ratings assigned to new furnaces and boilers. A new furnace or boiler should have an AFUE greater than 80%.

When you're looking for a replacement furnace or boiler, remember that the size of a heating system affects its efficiency. Because oversized furnaces cycle on and off, they operate less efficiently and create fluctuating heating cycles and less comfortable conditions than furnaces matched to the heating load. You'll probably want to select a replacement furnace that is smaller than the existing furnace, especially if you're also tightening up the building shell by insulating, replacing windows, and air sealing.

Energy-efficient furnaces: How much savings can you expect?

The following chart shows the savings you can expect if you replace a residential heating system with a more energy-efficient model.

Dollar savings per $100 of annual fuel cost

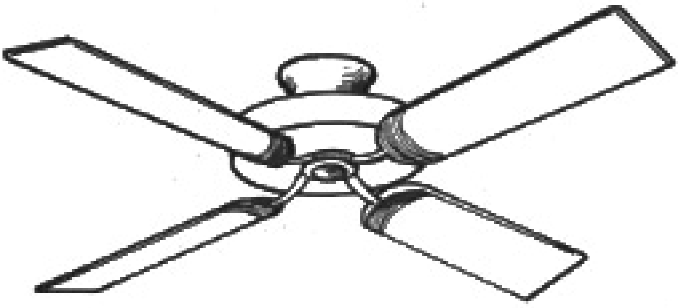
From an efficiency of:	To an efficiency of: 55%	60%	65%	70%	75%	80%	85%	90%	95%
50%	$9	$16	$23	$28	$33	$37	$41	$44	$47
55%		8	15	21	26	31	35	38	42
60%			7	14	20	25	29	33	37
65%				7	13	18	23	27	32
70%					6	12	17	22	26
75%						6	11	16	21
80%							5	11	16
85%								5	11

Ventilation

Good ventilation is essential in homeless housing to replace stale, stuffy, indoor air with fresh, outdoor air. Ventilation can be natural or mechanical. Natural ventilation, sufficient for small-scale facilities, involves opening windows and even doors in the warm months to take advantage of cool breezes. When designing your renovation, you can usually encourage cross-ventilation by placing windows on both the upwind and downwind sides of the building.

In tightly insulated houses or large-scale facilities, you may need to ventilate mechanically with fans. In practice, the code-required level of ventilation is generally inadequate to maintain proper indoor-air quality in homeless housing because of odors. Experience shows that in new or renovated buildings, your ventilation system should provide about three times the code-specified minimum level of ventilation.

Unfortunately, by increasing the ventilation level, you'll be paying to heat or cool substantially more air. In the summer, an economizer allows you to use outside air for ventilation when the outside air temperature is cooler than the indoor temperature. During the heating season, another way to maintain a high ventilation



rate without raising your utility bills is to use an air-to-air heat exchanger. This device transfers the heat from the exhaust air to incoming fresh air. Air-to-air heat exchangers can be used in residences or larger buildings and are most cost effective in buildings with large ventilation loads. When buying an air-to-air heat exchanger, avoid inexpensive units that may leak or are noisy.

Air Conditioning

Because air conditioning is costly, your first question should be, "Can I do without it?" If you're renovating a small-scale facility, consider using vegetation or exterior shading devices that allow you to rely solely on the natural ventilation methods we mentioned earlier. If cross ventilation alone is inadequate, an attic or ceiling fan may do the trick.

Another option is to use an evaporative cooler, which adds moisture to the air. As water evaporates into the air, humidity increases but the air temperature decreases. Evaporative cooling is most suitable in dry, western climates without excessive humidity.

If you decide that air conditioning is necessary, your next task is to find an energy-efficient model. There are two main

Taking Control

Many types of energy-management controls can reduce the energy consumption and electrical demand of mechanical systems. They include devices such as time clocks by which lights, water heaters, and other equipment can be switched on and off automatically. Other devices optimize the cycling time of heating, cooling, and ventilation equipment. Control systems range in price from several hundred to several thousand dollars. Simple, low-cost systems are usually the most cost effective and reliable. An energy-management control system for a new building will usually pay for itself in energy savings in 3–5 years.

The most basic control is a set-back thermostat. This is a good addition to any heating system, old or new, in single- and multifamily buildings. Typically, this device is used in the winter to automatically lower the temperature at night and raise it in the morning. Setting the temperature back by 10°F for 8 hours a night will cut the fuel consumption of a gas-fired system by about 7%. A set-back thermostat costs $40–$150 and will usually pay for itself in about a year.

types of air conditioners: room and central. Room air conditioners are placed in a window or wall to cool a single room. Central air conditioners, commonly used in large buildings, require a duct system to carry the cool air to the entire building. Although central systems have greater operating efficiencies, room air conditioners may be most cost effective if you only need to cool certain rooms.

Central air conditioners are rated according to their seasonal energy efficiency ratio (SEER). A typical new central air conditioner sold in 1991 had a SEER of about 10. Many older central systems have SEERs of only 6 or 7. Packaged central systems are sold for buildings up to approximately 15,000 square feet.

Room air conditioners are rated by their Energy Efficiency Ratio (EER). The higher the EER, the more efficient the unit. An EER of 8 is the minimum for a new 1990 unit; 10 or higher is excellent.

Hot Water Systems

Water heaters, like furnaces, are fueled by natural gas, oil, or electricity. A gas water heater costs less to operate than a comparable electric water heater.

If you have to use an electric water heater, consider using a heat-pump water heater. It heats the water by removing heat from the surrounding air and uses about one-third as much electricity as electric resistance water heaters. In many cases, a solar water heater can also compete favorably with an electric one.

The tank walls of older water heaters are poorly insulated. You can save energy by wrapping a water-heater blanket around the tank. An insulating blanket for a residential-size tank costs about $15.00 (materials only). When applied to an older-model water heater, a blanket can pay for itself in less than a year. For

Meeting Hot Water Demand

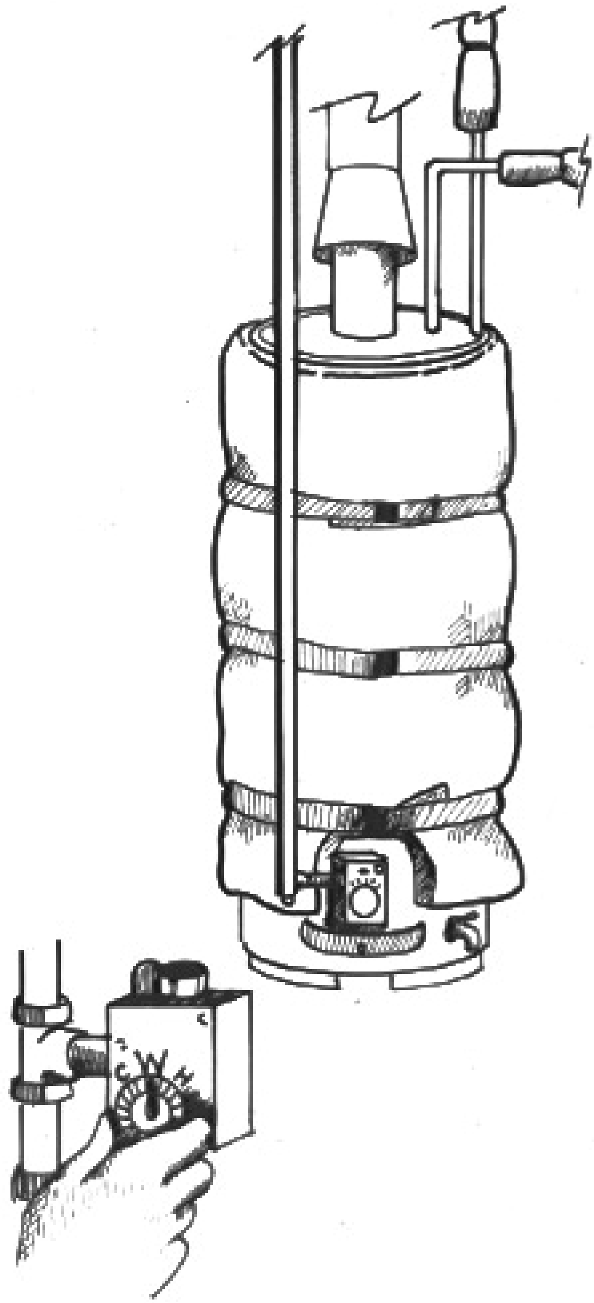
Many large homeless facilities have difficulty meeting their hot water needs. To avoid this problem, design the hot water system to meet the most typical worst-case situation, such as when all the residents take morning showers. Ask your engineer to explore at least two solutions so you can determine the most cost-effective one. For example, one solution is to use a small boiler and sufficiently large insulated storage tanks to meet your water-heating needs. Another is to use a large boiler and small storage tanks.

If you are remodeling a building and find that your water is being heated indirectly by a space-heating boiler, you may want to evaluate the cost effectiveness of replacing this method of water heating with a separate system. Indirect water heating may be satisfactory during the heating season, but during the summer, the boiler must continue running just to provide hot water. The most cost-effective option will depend on the relative size of water-heating versus space-heating requirements in your building and on your boiler's efficiency.

a larger building, you can add insulation to the storage tanks.

Because of recent government regulations, water heaters purchased after January 1, 1990, are insulated far better than older models. Newer electric models typically are insulated with 2 inches of polyurethane foam for an R-value up to 16. New gas water heaters are insulated with 1 inch of foam.

You can add an insulating blanket to your new water heater, but don't expect the dramatic savings possible with older models. When comparing new water heaters, compare the yellow EnergyGuide labels that give information on the cost of operation.



Lighting

The two most common categories of light bulbs are incandescent (the standard filament light bulb) and fluorescent. Both incandescent and fluorescent bulbs are available in energy-efficient styles; however, in general, fluorescents are much more efficient than incandescents. A standard fluorescent bulb is approximately *three times* as energy-efficient as a standard incandescent one.

When you're selecting lighting for your building, keep in mind that your choices are important in terms of both energy savings and aesthetics. With the proper lighting, you can save energy *and* create a comfortable, homelike atmosphere rather than the institutional feel common in many homeless facilities.

Use energy-efficient fluorescent lighting in activity areas, hallways, offices, cafeterias, laundry rooms, and common spaces. To create a homelike environment in sleeping or other private areas, install compact fluorescents in indirect lighting fixtures where the light is directed up and reflected down. If compact fluorescents don't fit, consider using halogen bulbs. For more institutional settings, vandal-resistant fixtures are available from virtually all fixture manufacturers. Design lighting systems that will allow your staff and residents to adjust lighting levels for specific activities by providing multiple switches or dimmer controls.

If your building is air conditioned, you can reduce your summer cooling bill by reducing your lighting energy; much of the heat that is removed by the air conditioner

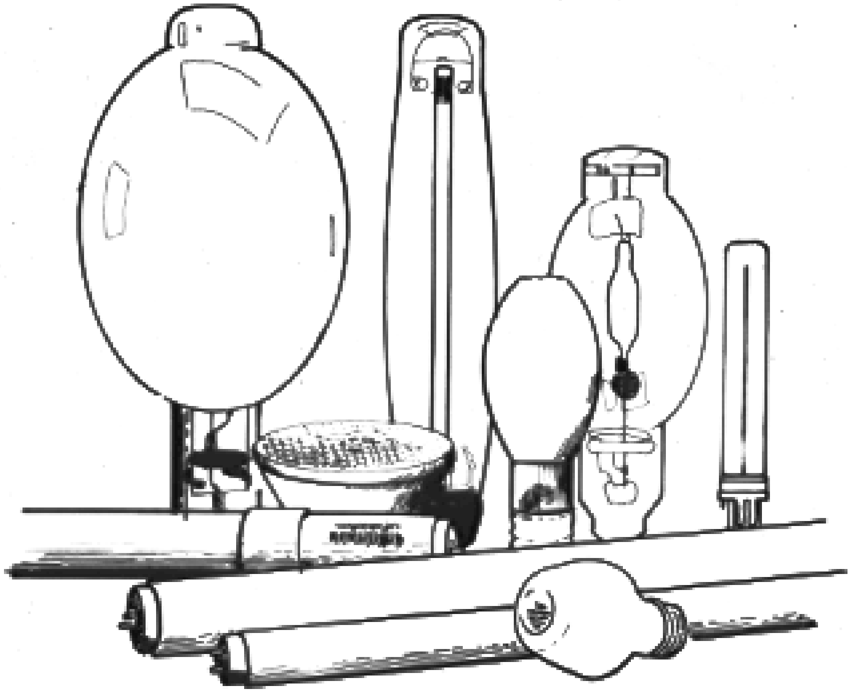
Lighting the Energy-Efficient Way

Here are several energy-efficient lighting options:

Compact fluorescent: *These differ from other fluorescents because they can be screwed into conventional incandescent sockets. They are bulkier than incandescents, though, and may be too long to fit in standard fixtures and table lamps. A compact fluorescent uses approximately one-third the energy of a standard incandescent lamp. Given the cost of both replacement bulbs and energy savings, these lamps save approximately $60 over their lifetimes.*

Halogen: *This is an efficient incandescent lamp that can be substituted for any existing incandescent lamps. In some instances, replacing a standard incandescent with a halogen lamp may reduce the energy use by 40%. This is true if you replace a 150-watt standard lamp with a 90-watt halogen one. The 90-watt lamp costs twice as much as the 150-watt lamp, lasts 2000 hours, and pays for itself in approximately 800 hours.*

Energy-efficient fluorescent: *Several energy-efficient fluorescent options are available that include more efficient lamps and electronic ballasts (devices used to start and operate the lamp) and reflectors (mirror-like materials that reduce the amount of light absorbed within a fixture). These fluorescent fixture options can reduce energy usage by up to two-thirds compared with standard fluorescents. Their payback is 2–4 years.*



is generated by lights. The more efficient the lights, the lower the required cooling.

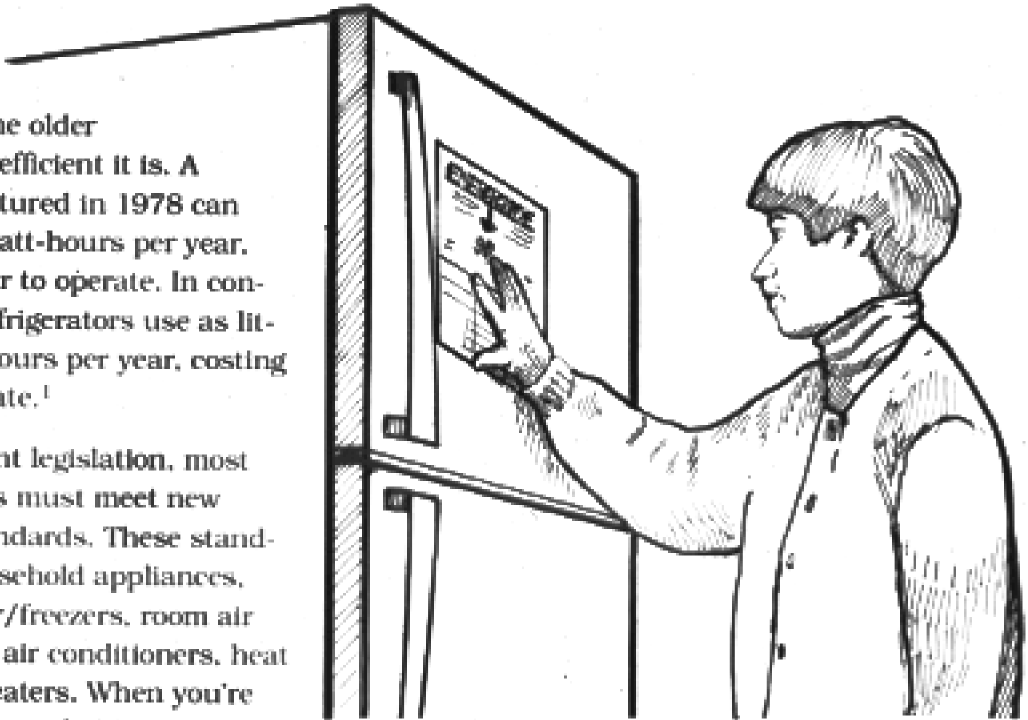
An occupancy sensor is a low-cost way to cut down on your use of lights. This device automatically shuts off the lights in an unoccupied room and turns them on when someone enters it. Occupancy sensors work best in rooms that are occupied briefly or periodically, such as meeting rooms. Two types of sensors are typically used: infrared and ultrasonic. Both detect motion within an area and trigger a switch that controls a lighting circuit.

You may also want to consider using natural lighting, known as "daylighting," as much as possible. Spaces that require daytime lighting, such as offices or counseling rooms, can be placed adjacent to properly designed windows and skylights. In these locations, add lighting controls so that artificial light can be adjusted to supplement the natural daylight. To include more sophisticated daylighting techniques, find an architect or lighting designer well versed in this area.

Appliances

If you're renovating a multifamily building, be wary of good deals on bulk purchases or donations of older model refrigerators or other appliances. The amount of money that you save when acquiring a used appliance may be more than offset by its high operating cost. Buying an energy-efficient appliance may cost more initially, but you benefit from reduced operating costs over the lifetime of the appliance. Also, try to plan for the most efficient *number* of any given appliances; an extra, underutilized refrigerator may not be justified, because of its operating costs.

The refrigerator is generally the major energy-consuming appliance; the older it is, the less energy efficient it is. A refrigerator manufactured in 1978 can consume 1600 kilowatt-hours per year, costing $112 per year to operate. In contrast, 1990-model refrigerators use as little as 700 kilowatt-hours per year, costing $49 per year to operate.[1]



As a result of recent legislation, most new home appliances must meet new energy-efficiency standards. These standards apply to 13 household appliances, including refrigerator/freezers, room air conditioners, central air conditioners, heat pumps, and water heaters. When you're shopping for a new household appliance, compare the energy-efficiency ratings on the yellow EnergyGuide labels. No standards exist for commercial-scale appliances.

If you operate a large facility with a commercial-scale kitchen, you may use a significant amount of energy preparing food. Some energy-efficient technologies for food preparation include a two-sided griddle, an energy-efficient fryer, and a combination oven/steamer.

The two-sided griddle saves energy by cooking food such as frozen hamburgers at lower temperatures than a standard griddle. You can get kits that convert a one-sided griddle to a two-sided griddle. An energy-efficient fryer has more insulation than others, and its electronic controls allow for greater reliability and more precise temperature control than are possible with a conventional fryer. An oven/steamer cooks in three cooking modes—steam, hot air, and combination—that use moist heat at lower temperatures and for shorter periods of time than conventional cooking.

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[1]These costs are based on $0.07 per kWh.